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TITLE: Air filter for domestic and industrial purposes, has inner and outer layer of active carbon and active cation exchange particles, zeolite and cation exchanged molecular sieve, respectively

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ABSTRACTED-PUB-NO: WO 200033940A

BASIC-ABSTRACT:

NOVELTY - A filter (1) has outer active carbon layer (2) and inner layer (3) of acidic cation exchanger, zeolite and cation exchanged molecular sieve with a fan (4) beneath inner layer. The sieve is chosen from group of a high efficiency particulate air filter, fiber filter, membraneal filter and filter with active carbon fibers, to filter out particles as per size. Air pump, air blower or electrostatic force capable of mobilizing air activated by solar energy, help to mobilize air to be filtered and purified.

USE - For household purposes such as for living room, for children rooms, for office, etc. For filtering urine odor in toilets, public urinaries, children's rooms, hospitals, etc. For shelters against chemical and/or biological warfare. For placement in confined spaces such as in mines, inside car. For livestock industry such as in barns, pigsties, hen houses etc. For computers, TV, CD player, etc. For tobacco containing cigarette and medicinal cigarette.

ADVANTAGE - The fan can be positioned in any place, preferably beneath innermost layer. Spatial arrangement of the device can be varied as per the intended purpose.

DESCRIPTION OF DRAWING(S) - The figure shows the schematic representation of arranging various layers of the device.

Filter 1

Outer active carbon layer 2

Inner layer 3

Fan 4

CHOSEN-DRAWING: Dwg.1A/3

TITLE-TERMS: AIR FILTER DOMESTIC INDUSTRIAL PURPOSE INNER OUTER LAYER ACTIVE
CARBON ACTIVE CATION EXCHANGE PARTICLE ZEOLITE CATION EXCHANGE
MOLECULAR SIEVE RESPECTIVE

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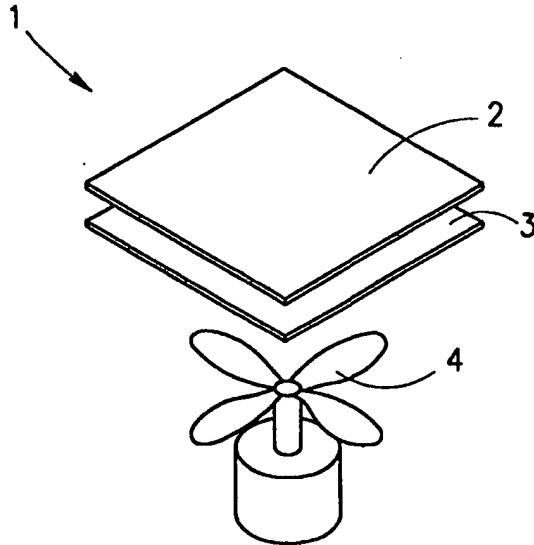
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(54) Title: AIR FILTER

(57) Abstract

The invention concerns a filter (1) for the purification of air comprising a layer (2) of active carbon and a second layer (3) composed of an acidic action exchanger, zeolites or cation exchanged molecular sieves.



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AIR FILTER

FIELD OF THE INVENTION

This invention relates to devices for the filtration and purification of air.

BACKGROUND OF THE INVENTION

The quality of air is a growing concern worldwide, especially in the developed world. It is well known today, that various air pollutes can cause severe infectious diseases in the air ducts, and may even lead to premature death. The causes of these health hazards are compounds termed "*particulate compounds*". This term refers to a wide variety of polluting material emitted as fluid, or solid particles from various sources such as vehicles, combustion engines, smoke, industrial engines, etc. The particulate compounds may also be from natural sources such as pollen or plant particles, bacteria, virions, and other microorganisms. These particles are deposited in the air ducts, and may lead, after various exposure periods to allergies, headaches, asthma, pre-disposition to infectious diseases, and in extreme cases may also lead to cancer.

Various means, and devices have been constructed in order to purify and filter air from these particulate compounds. Most devices are based on some sort of sieves, for example, a paper filter, together with active carbon which is known to absorb a wide variety of gases as well as particulate compounds. Air is mobilized through the filter and the active carbon by the use of a fan, a pump or blower. While these simple devices are suitable for filtering out dirt and dust particles by the filter and absorbing various gases such as chloroform, butane and propane on the active carbon, they usually are incapable of filtering and purifying various odors, noxious agents and the like.

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In addition, humidity and dust particles which come into contact with the active carbon quickly saturate it, reducing dramatically its ability to absorb particles.

Other prior art devices purify air by ionization process. The amount of air purified is limited by the rate of ion emission and the ozone level. In addition, these ionizing devices can cause static electricity and are thus unsuitable for use in the presence of inflammable gasses such as those used in operating rooms and in cooking areas.

Zeolites are alumina silica minerals that contain alkali and alkaline-earth metals, such as sodium, potassium and calcium as well as water molecules within their structural framework. The framework is relatively porous, enclosing inter-connected cavities in which metal cations and water molecules resides.

The cations and water molecules have a considerable freedom of movement within the framework of aluminium, oxygen, and silicon atoms and this gives the zeolites cation-exchange and reverse dehydratin properties. The porous framework of the zeolites enables them to act as molecular sieves which are able to separate molecular mixtures on the basis of the size and shape of the molecular compounds, or enables the selective absorption of gasses thereon. These unique properties are utilized in diverse industrial processes such as the purification of water and other liquids, purification of gasses, chemical separation, catalysis, and decontamination of radioactive waste and are used especially in catalytic converters, in order to purify exhaust gas emitted from internal combustion engines, such as from vehicles.

Cation exchange particles, are polymers having cation exchange groups for example carboxylic, sulfonic, etc. and are usually used in filtering, and cleansing of liquids such as water, or for various laboratory purposes.

SUMMARY OF THE INVENTION

The present invention provides a device for filtration and purification of air comprising:

- 3 -

- at least one layer of active carbon; and
- at least one layer of a particle-absorbing-agent selected from the group consisting of:
 - acidic cation exchanger;
 - zeolites;
 - cation exchanged molecular sieve.

5 Optionally, the device of the invention also includes means for mobilizing the air to be filtered and purified through said layers.

The device of the invention is suitable for any purpose where ambient air
10 (which is not exhaust fumes emitted from engines) is to be filtered. Typical uses of the device of the invention, are for household purposes, such as for living rooms, for childrens' rooms, for offices, etc. Due to the fact that the device of the invention is especially suitable for filtering urine odors, the device is particularly suitable for toilets, public urinaries, childrens' rooms, hospitals, etc.

15 In addition, the device of the invention is suitable for shelters, including shelters against chemical and/or biological warfare, is suitable to be fitted as a part, of or in connection with, pre-existing air-conditioning systems, is suitable for placement in small industrial spaces, such as in garages, or suitable for placing in confined spaces such as in mines and inside cars and is also suitable for livestock
20 industry, such as to be fitted in barns, pigsties, hen houses, etc.

In addition, the device of the invention can be used in the vicinity of dust-and dirt-sensitive devices such as computers, TVs, CD players, etc.

Finally, the device of the invention may be used as a filter for cigarettes including both tobacco containing cigarettes and medicinal cigarettes made from
25 various herbs. The cigarette filter can be a combination of zeolites and active carbon either mixed together as a mixture or present as a distinct layer of zeolites and/or cation exchange particles and a layer of active carbon. The filter can be integral with the cigarette or detachable therefrom for replacement. The cigarette filter may be formed within a state of the art cigarette present in most
30 commercially available cigarettes.

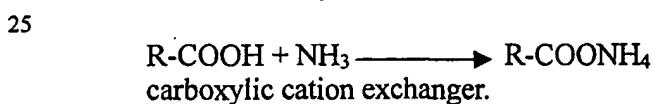
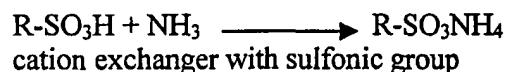
- 4 -

The air can be filtered and purified from the following undesired components: dust particles, urine odors (caused by NH₄⁺ ions), small particles emitted by industrial paint, or industrial machinery; infectious agents such as bacteria, virus and parasites, especially those present in livestock industry; pollen; 5 smoke including cigarette smoke; smog; dust and various other particles. The filter may also be installed in a welding helmet as well as placed in bicycle and motorcycle riders' helmets for the purpose of purifying air.

The device of the invention includes as one of its components at least one layer of active carbon. The active carbon may be in an essentially continuous form, 10 i.e. present as compact dust held by a net or by a filtering membrane; in a particulate form; present as a grid or sieve composed of fibers of active carbons; present as parallel carbon fibers or present as a porous, sponge-like substance. Where the carbon is porous, or structured in preferably the form of a grid, a sieve or parallel fibers which can serve also as a means for mechanically filtering out the 15 particles according to their sizes as will be explained herein below.

The device of the present invention, further comprises a layer composed of an agent which can actively absorb and/or exchange particles termed hereinafter "particle-absorbing-agent".

The particle-absorbing agent may be composed of acidic cation exchangers, 20 being agents capable of exchanging cations, or of absorbing ammonia. The cation exchange polymer may be in the form of an acid or can be a cation exchange membrane. Examples are exchangers according to the following equation:



30 Ammonia is the predominant material which causes a urine smell, thus by using cation exchangers in acidic form smell of urine can be eliminated. In

addition, ammonia smells are produced in various reactors in industry, garages, iron mills, etc.

By another alternative, the particle absorbing agents can be cation exchange molecular sieves. Molecular sieve (MS) is a porous crystalline solid with 5 framework based on an extensive three-dimensional network of oxygen ions containing generally tetrahedral-type sites occupied by cation T (Si^{+4}), Al^{+3} , other cations can also occupy tetrahedras T namely: As, B, Be, Co, Cr, Ga, Fe, In, La, Mg, Mn, P, Sb, Sn, Ti, V, Zn, Zr etc.. When the tetrahedra is AlO_2 , the framework is charged and the charge is balanced by exchangeable cations that occupy 10 non-framework positions. Typical cations include: the alkaline (Na^+ , K^+ , Rb^+ , Cs^+) and alkaline earth (Mg^{+2} , Ca^{+2}) cations, NH_4^+ , H^+ , tetralkylammonium and other N or P containing cations, and the rare earth and noble metal ions. Zeolites are a specific case of the molecular sieve belonging to silicas group of MS's more detailed to metallosilicates (Szostak, I.R., Molecular Sieve, Principles of Synthesis 15 and identification, Van Nostrand Reinhold, Catalysis Series, New York, 1989).

Especially preferred in accordance with the invention, are cation exchange zeolites which are Ca-, Ba-mordonite which can absorb only gases with critical size less than 3.8 Angstrom (He, Ne, Ar, H_2 , O_2 , NH_3 , H_2O), zeolite 4A (which absorb CH_4 , CH_3OH , CH_3CN , CH_3Cl , CH_3Br , CO_2 , C_2H_2 , CS_2), zeolite 5A (which absorb 20 all compounds mentioned above and also C_3H_8 , n- C_4H_{10} , n- $\text{C}_4\text{H}_3\text{O}$, $\text{C}_2\text{H}_5\text{OH}$, $\text{C}_2\text{H}_5\text{NH}_2$, CH_2Br_2 , CHF_3 , CH_3I , $(\text{CH}_3)_2\text{NH}_2$ etc.), zeolite 10X (which can also adsorb 8-9°A molecules), zeolites Y and X (which can adsorb 1,3,5 – trietylbenzene with 10°A size), a natural zeolite named clinoptilolite (capable of absorbing the following absorbing gases: SO_2 , H_2S , NH_3 , CO, CO_2 , H_2 , N_2 , H_2O).

25 The MS's are able to separate molecular mixtures on the basis of the size and shape of the molecular compounds or enable the selective absorption of gases.

These unique properties are utilized in diverse industrial processes such as the purification of water and other liquids, purification of gasses, chemical separation, catalysis and decontamination of radioactive waste.

Optionally the device of the invention further comprises means for mobilizing the air to be filtered and purified through the above at least two layers. The means may be an air pump, an air blower, (for example, of the suck-and-blow configuration) a fan which can mobilize air, in a predefined direction, i.e. from the outer environment, through said layers, and back to the outer environment. The air pump, air blower, or fan, may be a part of the device, or may be a part of a larger air control device, such as a part of an air-conditioning system, and in that case, the device is a hybrid, comprising the above layers, for example, present as a cassette, placed over a pre-existing air transferring means, such as a pre-existing air-conditioning systems. The means, may also be means for providing electrostatic forces which are also known to mobilize air. The air mobilizing means can be powered by electricity, by battery or by solar energy, for example, where the filter is used to filter air within cars.

In accordance with a preferred embodiment of the invention, the device of the present invention further comprises a sieve which can filter out particles according to their sizes.

The sieve may be any compound having an essentially uniform porous distribution, such as high efficiency particulate air filter (HEPA), a fiber filter, a filter composed of various membranes such as paper, cloth, polyester, a polypropylene or a nylon filter construction, a sieve made out of silicon and Teflon™, etc.

The various layers, sieves and means for mobilizing air, may be arranged in several manners, in accordance with the desired purpose of the device.

In order to construct a basic and cheap device for filtering and purifying air, for example to be placed in bathrooms and urinaries, the device may comprise as an outer layer active carbon, preferably in the form of carbon fibers, which besides the activity of absorbing particles, may also serve as a sieve filter particle according to size. Beneath this active carbon, there should be an inner layer of acidic cation exchanger and/or zeolites. The basic device is very inexpensive and simple. Such basic device may also be used as a filter for cigarette smoke. Optionally, the basic

device may be equipped with a fan, present beneath these layers, capable of mobilizing air through the active carbon fiber and cation exchange layer. Such a simple arrangement, may be positioned directly inside the toilet bowl, in the outcoming pipe from the toilet bowl, or in the vicinity of the toilet bowl, in order to
5 filter out urine smells.

By another option, suitable for example for placement in various rooms of the house, the device of the invention has the following layer arrangement: as an outer layer, a sieve, being any of the sieves specified above. Beneath the sieve, as a second intermediate layer is an acidic cation exchanger, and/or zeolite preferably
10 cation exchanged zeolites; and finally as the innermost layer, active carbon. This arrangement, ensures that the largest particles are first filtered out by the sieve according to their size. Then, the intermediate cation exchange or zeolite layer, filters out the following components: H₂, NH₃, CH₃OH, CH₃CN, CH₃Cl, CH₃Br,
CO₂, C₂H₂, CS₂, C₃H₈, n-C₄H₁₀, n-C₄H₃O, C₂H₅OH, C₂H₅NH₂, CH₂Cl₂, CH₂Br₂,
15 CHF₃, CH₃F₃, CH₃I, (CH₃)₂NH₂ and most particularly eliminates moisture present in the air, so that the active carbon (which is present in the innermost layer) comes into contact with relatively dry and purified air, and thus can act for long periods of time without becoming saturated.

Another option, suitable for eliminating moisture in closed spaces such as
20 closets or refrigerators (to avoid smell and development of mold) comprises as an outer layer fibers of active carbon, as an inner layer, a sieve, and as the innermost layer, an acidic cation exchange layer. Such an arrangement is simple, inexpensive and does not require the presence of a fan.

The fan in any of these arrangements can be positioned in any place which
25 ensures the transfer of ambient air through the layers, and out again, and preferably is beneath the most innermost layer.

The ratio between the various layers, should be preferably 1:1, w/w, or 1:1, surface area region to surface area region (in sq. cm) so that all the layers are saturated essentially after the same period of time by the various particles, and all
30 of them should be replaced together by new unsaturated layers at the same time.

The various layers of the device, may be structured as a single cassette, which can be removed, and replaced by a new cassette with new layers which unsaturated by filtered out particles.

5 The spatial arrangement of the device can be varied according to the intended purpose. For simple household uses, an essentially flat layered arrangement can be used, and this can ensure that the bulk of the device is relatively small, so it may be hung inside a car, placed inside a room, etc.

10 However, for industrial purposes, or for filtering out air in livestock housing where the amount of air to be purified and the amount of particles to be filtered out is large, the device may be constructed so as to increase its surface area, in order to facilitate contact between the various layers and the ambient air, for example, by constructing the device's layers to have many perfusions and depressions on its surface; by constructing the layers in a spherical manner, etc.

15 For the purpose of increasing the efficiency of the particle-absorbing- agent layer in absorbing and/or exchanging particles, this layer can be fitted with a heater. It is well known that zeolites as well as cation exchangers increase the efficiency of absorbance/exchange respectively with an increase of temperature especially at room temperature to a temperature of several hundreds of degrees.

20 The present invention further concerns a cassette for use in connection with air-mobilizing means comprising:

- at least one layer of active carbon;
- at least one layer of a particle-absorbing-agent selected from the group consisting of:
 - acidic cation exchanger;
 - zeolites;
 - cation exchanged molecular sieve.

25 The cassette may be obtained separately to be placed as on a disposable component of the device of the invention, and in that case the device of the invention further comprises a housing for holding the cassette.

Alternatively, the cassette may be constructed so as to be placed in pre-existing air mobilizing means such as for placement above fans, ventilators inside air-conditioning systems and the like.

BRIEF DESCRIPTION OF THE DRAWINGS

5 In order to understand the invention and to see how it may be carried out in practice, a preferred embodiment will now be described, by way of non-limiting example only, with reference to the accompanying drawings, in which:

Fig. 1A, 1B and 1C shows a schematic representation of three options for arranging the various layers of the device of the invention;

10 Fig. 2 shows a device constructed to be placed in the vicinity of a toilet bowl; and

Fig. 3A, 2B and 3C shows various constructs of the device for household usages;

15 DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Fig. 1 shows three alternative manners for arranging the various layers of the device of the invention.

Fig. 1A shows the device 1, suitable as a basic inexpensive device for example to be placed in toilet rooms or cars. The device comprises an outer layer 2 made of carbon fibers preferably present in the same orientation. Beneath layer 2, comes layer 3 made of cation exchange particles, zeolites, or acidic cation exchanged molecular sieves held in place by suitable net or restraining structures or by gluing the particles to the layer below.

Beneath the two layers, a fan 4 is present. Such an arrangement ensures that 25 ambient air first passes through active carbon fibers, and particles in the air are both actively absorbed thereon, and filtered according to their sizes (due to its sieve-like properties) and then the relatively cleaned air is mobilized into zeolites/or cation exchange layer so that the remaining particles, ions and odors can be filtered out.

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The device shown in Fig. 1B, has a more complex arrangement, and is suitable for household purposes. The device 5, comprises as an outer layer, sieve 6, for example, a paper filter capable of filtering out particles according to size. Beneath the paper filter, comes a layer 7 of particle-absorbing-agents, such as 5 cation exchange or zeolites as explained above.

Beneath this layer, comes a layer 8 of active carbon. And at the innermost part of the device, is present fan 9 which ensures mobilization of the air through the various layers.

Fig. 1C shows the device 10, having as an outer layer active carbon 10 fibers 11, beneath them a layer 12 of sieve such as a high efficiency particulate air filter (HEPA) and beneath that the layer of particle-absorbing- agents 13. such as cation exchange particles.

The fan 14 is present at the innermost part of the device.

Fig. 2 shows device 20 to be placed in the vicinity of toilet bowl 21, 15 comprising to filtering and purification parts 23. Parts 23, are composed of the basic filter, shown in Fig. 1A, wherein the uppermost part 24 is made of a layer of active carbon and acid cation exchange resins, suitable for filtering out NH_4^+ ions which cause urine odor, and beneath them, is fan 25. The air is mobilized so that is moves from toilet bowl 21, through air channels 22, then filtered and purified 20 through layers 24, with the aid of fan 25, and then is emitted again outside.

Fig. 3A, B and C show three different constructs for devices for household uses 31, 32 and 33, respectively. In each device, there is present layers of active carbon/zeolites/sieves, according to any one of the options of Fig. 1A, 1B or 1C, represented in Fig. 3A as 34, in Fig. 3B as 35 and in Fig. 3C as 36. The air 25 mobilizing means in Fig. A and B is a fan 37 and 38, respectively, and in Fig. 3C is an air pump 39.

The ambient air rose in the direction of the arrows, with the aid of air transferring means, through the various layers.

CLAIMS:

1. A device for filtering and purifying air comprising:
 - at least one layer of active carbon;
 - at least one layer of a particle-absorbing-agent selected from the group consisting of:
 - acidic cation exchanger;
 - zeolites;
 - cation exchanged molecular sieve.
2. A device according to Claim 1, further comprising means for mobilizing the air to be filtered and purified through said layers.
3. A device according to Claim 2, wherein said means are selected from the group consisting of:
 - an air pump, an air blower, fan, or means for producing electrostatic forces capable of mobilizing air.
4. A device according to Claims 2 or 3, wherein the means for mobilizing air are activated by solar energy.
5. A device according to Claims 1 or 2, further comprising a sieve for filtering out particles according to size.
6. A device according to Claim 5, wherein the sieve is selected from the group consisting of:
 - high efficiency particulate air filter (HEPA), fiber filter, membranal filter, and a filter composed of fibers of active carbon.
7. A device according to Claim 1, comprising as an outer layer fibers of active carbon and as an inner layer acidic cation exchange particles or zeolite particles.
8. A device according to Claim 5, comprising as an outer layer a sieve, as an intermediate layer an acidic cation exchange particles and/or zeolites and as an inner layer an active carbon.

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9. A device according to Claim 5, comprising as an outer layer fibers of active carbon, as an intermediate layer the sieve, and as an inner layer acidic cation exchange particles.

10. A device according to any one of Claims 7 or 8, comprising a fan present
5 beneath the inner layer.

11. A device according to Claims 7 to 10, comprising in the layer of cation exchange particles and/or zeolite particles a heater capable of increasing the temperature of said particles.

12. A device according to Claim 1, constructed as a filter of a cigarette.

10 13. A cassette to be used in connection with air mobilizing means comprising:

- at least one layer of active carbon;
- at least one layer of a particle-absorbing-agent selected from the group consisting of:
 - acidic cation exchanger;
 - zeolites;
 - cation exchanged molecular sieve

15 14. A cassette according to Claim 13, to be used as a disposable element of the device of Claim 2.

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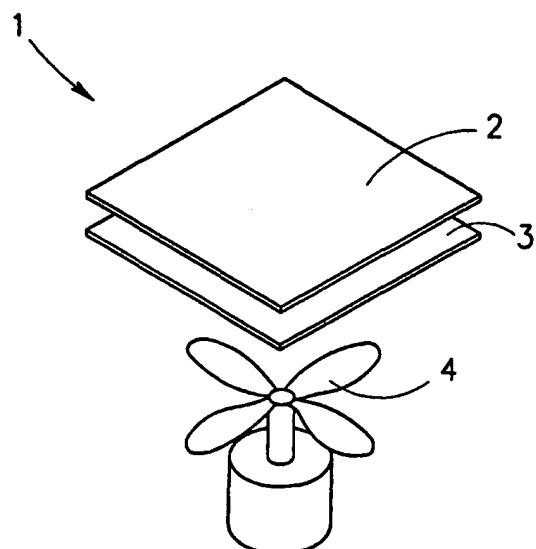


FIG. 1A

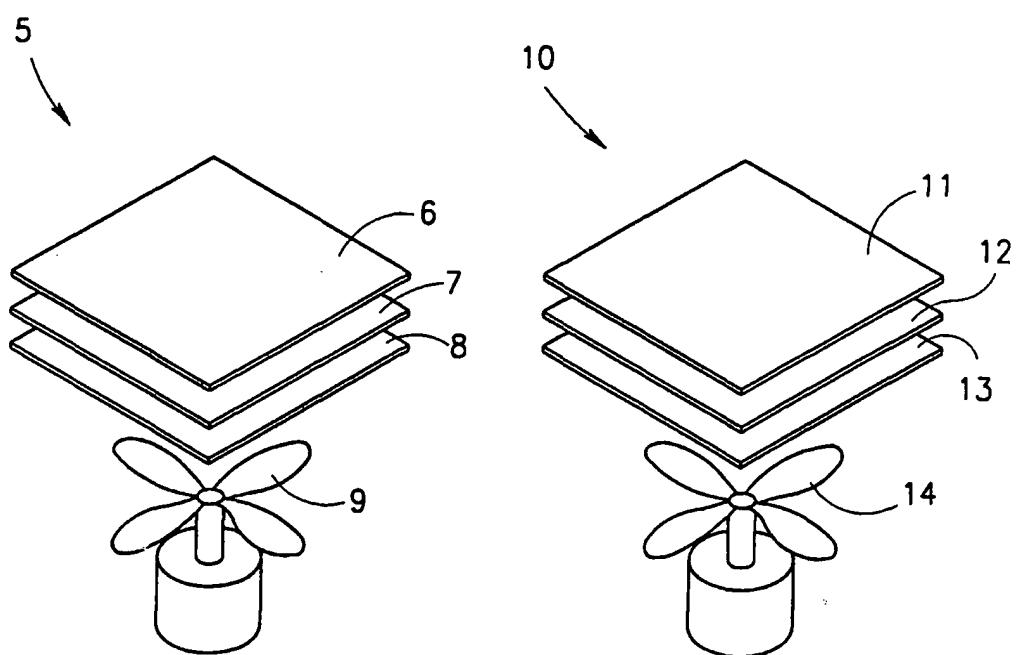


FIG. 1B

FIG. 1C

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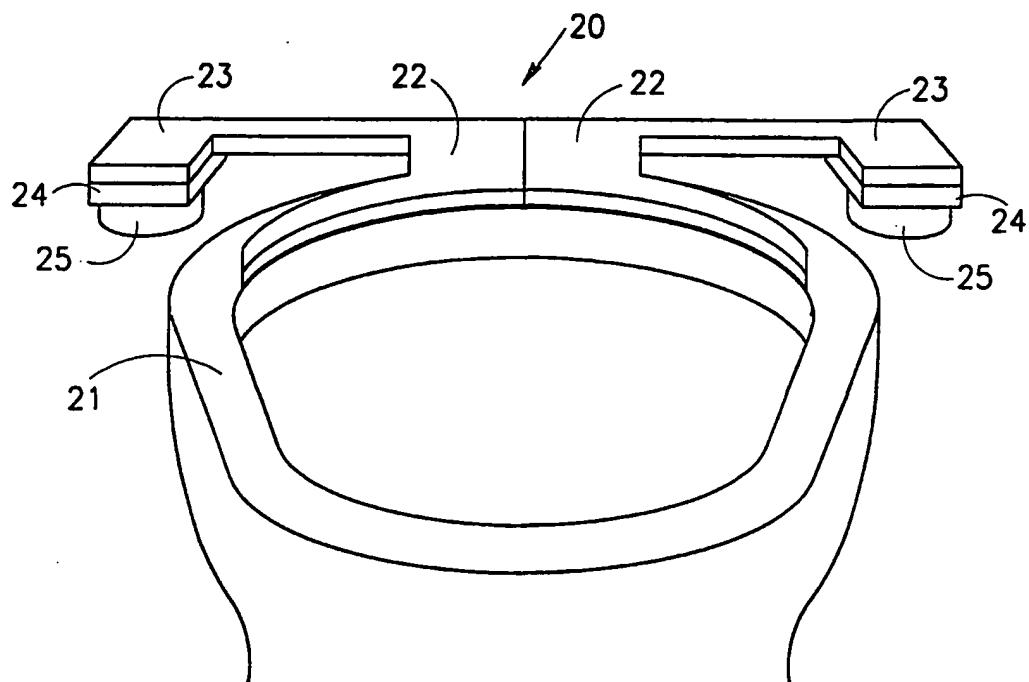


FIG.2

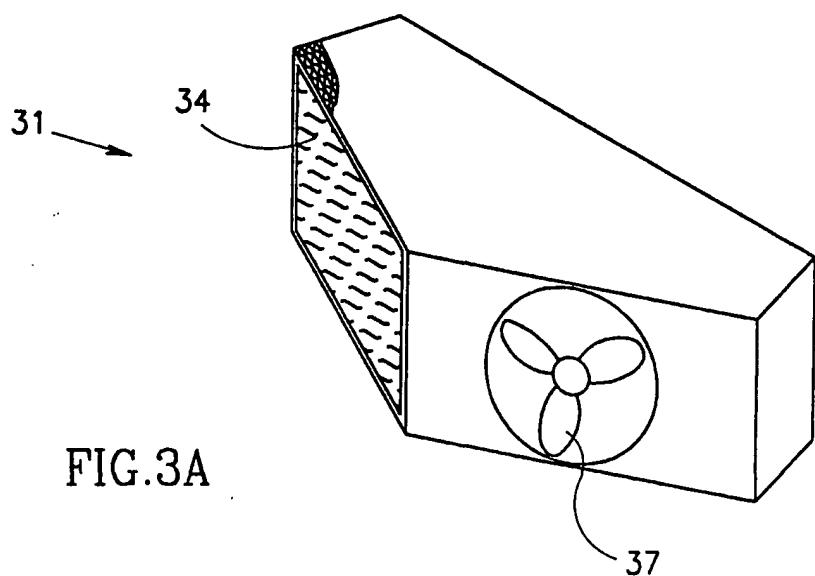


FIG.3A

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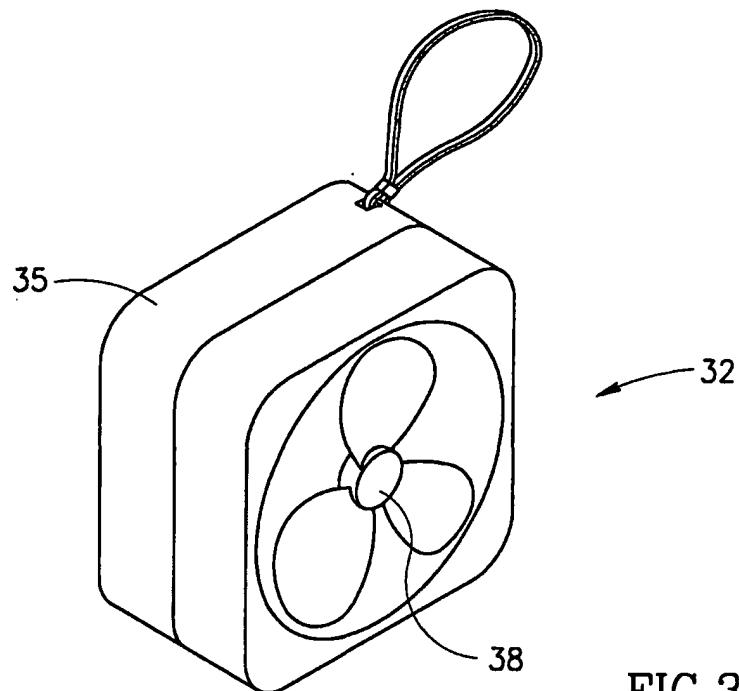


FIG.3B

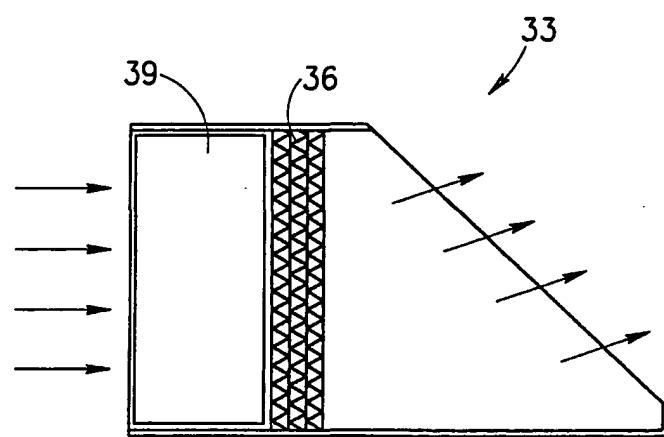


FIG.3C

INTERNATIONAL SEARCH REPORT

Int'l. Appl. No.
PCT/IL 99/00664

A. CLASSIFICATION OF SUBJECT MATTER
 IPC 7 B01D53/04 B60H3/06 A61L9/014 F24F3/16 A24D3/16

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B01D B60H A61L F24F A24D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the International search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 021 435 A (HOELTER H) 5 December 1979 (1979-12-05) page 3, line 30 – line 65 page 3, line 93 – line 113; figures 4-7	1,2,5-9, 13,14
X	DE 30 02 409 A (HOELTER HEINZ ING GRAD) 30 July 1981 (1981-07-30) the whole document	1-3, 5-10,13, 14
X	WO 86 04553 A (HOELTER HEINZ) 14 August 1986 (1986-08-14) page 2, paragraph 2 –page 3, paragraph 1 page 5, paragraph 2; figure 1	1-3,7,10

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

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Date of the actual completion of the International search	Date of mailing of the International search report
20 March 2000	24/03/2000

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INTERNATIONAL SEARCH REPORT

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X	US 5 348 563 A (DAVIS GEORGE B) 20 September 1994 (1994-09-20) column 5, line 36 – line 53; figure 4	1-3, 5-10,13, 14
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